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ABSTRACT

Reviews publications supporting the concept that carefully planned special characteristics of a classroom can facilitate desired activities both for the teacher and students. The author denotes these facilitating associations as the "suggestiveness of space," and applies the term "limiting conditions" to spacial characteristics which prevent particular activities. In designing science facilities the architect should be acquainted with the needs of the room which determine spacial requirements. A list of specific findings which help in designing better schools is provided. (PR)

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PLANNING THE TEACHING ENVIRONMENT: SECONDARY SCIENCE FACILITIES

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The superintendent contemplating a building program desires to improve the science curriculum in his school system. A principal ponders how to get his teachers to try CHEM Study. The department chairman wonders if he can ever have inquiry-centered teaching performed by most of his staff. The teacher wonders if it is all worth the effort.

The problems connected with improving science instruction are many—including teacher training and acquisition of equipment and supplies. Tonight I wish to dwell on one facet of improving science teaching—the important and intriguing task of creating environments which facilitate certain teaching methods.

I should emphasize that the idea that facilities are a major determinant of teaching method is not widely held among administrators. Some educators feel that, with proper training, good science teachers can improvise and overcome any shortcomings in their facilities. With a taxpayers' revolt in full swing, the situation will worsen. According to a recent SCHOOL MANAGEMENT Cost of Building Index survey,* 20 per cent of New England secondary schools with construction starting in 1970 will be without science laboratories. This compares to 25 per cent of the nation's new schools not having science laboratories. There may be good reason for this disdain of expensive laboratory facilities among certain groups of educators. In the past, research has been unable to justify clearly the need for laboratory work in science instruction. The secret to this situation

* Furno, Orlando F., and J. E. Doherty, 1970, "Specialized Facilities in Today's New Schools," SCHOOL MANAGEMENT 14:8, p. 17. (See also 13:1, p. 54, for definitions of geographical categories.)

lies in the type of goals reflected in the measuring instruments used during the last few decades. As we break away from "product" or "content" orientation and adopt more "process" or "inquiry" goals, the need for laboratory work must be reevaluated. Unfortunately, we still await breakthroughs in test and measurement practice. We can, however, look to teaching methods as our criteria for instruction. For instance, on the basis of teacher performance, we can challenge the person who claims that science can be taught in a subdivided auditorium. We can seriously ask—can a teacher be expected to teach inquiry science in situations demanding high amounts of improvisation (as in the auditorium example)?

There are others, probably most architects for instance, who feel that the design characteristics of a building (architectural space) actually would influence the thought and actions of an occupant. Not a few teachers have felt the inconvenience (and sometimes nonfunctionality) of their own school buildings. Even when searching for appropriate spatial characteristics, it is a frequent experience in my firm's line of work to encounter a wide variety of opinions concerning the proper design of science facilities.

While in graduate school, it seemed to me that research techniques might be applied to some of the real problems facing school designers and teachers. The first general task was to see if spatial characteristics did make a difference, even with imaginative teachers who would be most prone to improvisation. The second task was to gain some specific knowledge on what characteristics seemed more suitable for certain teaching methods by virtue of association. (If no associations occurred in actual school data, the theory of any cause and effect relationship would be in serious question.)

The first stage in developing what was to be called the Facilities Research Project was to think out a theory of facilities which would lead to prediction of certain relationships to be tested by field study. This document* was written while I was a student under Fletcher Watson and under the guiding wing of Douglas Roberts. I must admit that some people wondered why I had picked such a mundane topic for research as facilities, but consolation was obtained from the excellent reception I received from administrators who faced practical problems in school construction. Any of you who are contemplating research projects should consider the challenge of this exciting facet of environmental planning.

The dream of some environmental planners is to influence thought through creating significant environmental cues or catalysts that help form what some would call the Gestalt of the classroom teacher. At the least, the environmental planner desires to facilitate the anticipated activities of the teacher and students.

This brings up a hypothesis yet to be substantiated. Assume your role as a scientist investigating a phenomenon. Since research** has shown that certain actions are significantly associated with certain architectural characteristics, what is the explanation of the association?

The most intriguing and elusive causal explanation centers around what I choose to call the "suggestiveness of space." The connotations of some women's suggestive style of dress serves as a splendid example, but let me choose a more homely example. Many of you have probably had the experience of walking through a building and spying an

* D. F. Engelhardt, 1966, Space Requirements for Science Instruction: Grades 9-12. ERIC No. ED 022 353.

** D. F. Engelhardt, 1968, Aspects of Spatial Influence on Science Teaching Methods. ERIC No. ED 24 214.

———1970, Research Report No. 5: Architectural and Administrative Considerations for Science Teaching. Obtainable on loan from the ERIC Information Analysis Center for Science and Mathematics Education, 1460 West Lane Avenue, Columbus, Ohio 43210. Requests should include the document's number SE 008 245.

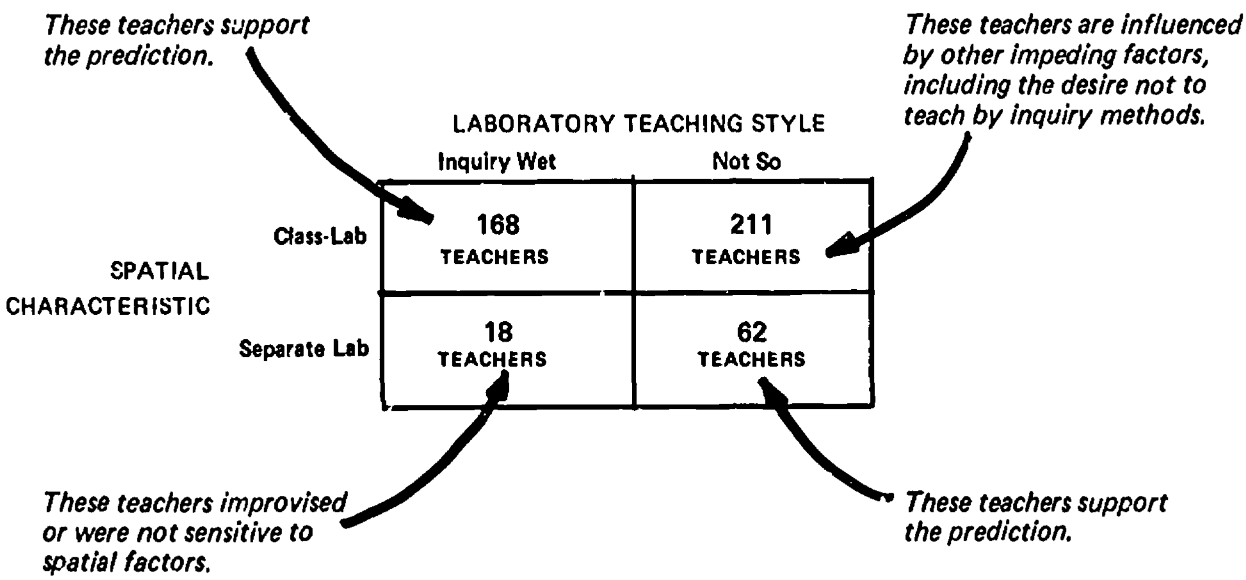
attractive water fountain. Even though you were not searching for a fountain and not particularly thirsty, the sight of the fountain may have awakened a thirst for water within you. In anthropomorphic terms, one could say that the water fountain suggested to you the thirst which led you to partake of the fountain's cool, refreshing water. In this case, a facility is suggesting activity, not merely permitting it to occur.

Another explanation of the detected associations lies in space permitting or impeding certain activities. Ecologists often speak of "limiting factors" in the environment which when at a certain level become "limiting conditions," influencing such things as the distribution of certain species. Let us expand this concept to a teacher in the classroom.

Can we not study how certain spatial characteristics prevent particular activities? Even though improvisation is always possible, could we not investigate the likelihood of a physics teacher studying optics in a room having poor ventilation and darkening ability versus an air-conditioned, nearly windowless room? (Sunlight has been suggested to be more of a contaminant in scientific investigations than a necessary factor.) Sunlight is a limiting factor, which could be a limiting condition for some activities.

Let us look at an example in past research which may exemplify both options in explanation. Suppose our theorizing has led us to the prediction that teachers in classroom-laboratories will tend to stress inquiry, with "hands-on" wet laboratory experience, more than teachers having to move to a separate laboratory facility. We then are searching for an association between an architectural design characteristic and a teaching method. Statistics have been gathered on this question (see page 10 of our Research Report No. 5). Figure 1 shows the number of teachers who responded in personal interviews so as to be classified as to teaching style. The facilities were also classified.

FIGURE 1



Significance (p) = .001 Phi = .17 Max Phi = .63

The explanation of suggestiveness would say that a constant laboratory environment might "suggest" the process of science as an activity base rather than a rhetoric of conclusions gained through scientific enterprise. The concept of "limiting factors" is explained by two major criticisms for separate facilities.

1. Separate laboratories are usually scheduled in order to achieve economy with fewer laboratories than science classrooms. The schedule does not allow appropriate timing of inquiry-laboratory exercises.

2. Most inquiry courses have common times where extended laboratory work is done. One such time is often during the first week of school, when a proper orientation to laboratory activity is nurtured.

The anecdotal remarks for the two groups of 18 and 211 teachers help us to understand what other factors are involved. It is a tribute to teacher training programs, summer institutes, and the perseverance of teachers that 168 teachers had their methods qualified as wet inquiry. Examples (see Research Report No. 5 for details) of other impediments were tabulated in the group of 211:

Poor facilities and equipment (8 teachers had no preparation time)	20 teachers
Advanced Placement exam preparation	14 teachers
Second course given in prenursing or "medical" skills	9 teachers
Team teaching with a special laboratory teacher	7 teachers

Examples of improvisation within the group of 18 teachers involved:

Open laboratories, modular scheduling	3 teachers
Other rooms always available	2 teachers

The use of anecdotal remarks usually makes best sense in subsequent research. Anecdotal remarks are not consistently noted and may be conservative in number of teachers.

However, it may be of interest to you to note the following administrative procedures which impede inquiry use of classroom-laboratories taken from page 12 of Research Report No. 5:

1. Team teaching can hinder the appropriate timing of inquiry-laboratory exercises if a certain teacher is responsible for discussion and another person for laboratory work.

2. Some student schedules disperse students from one class section to different laborotory sections. Therefore, even though students constantly meet in classroom-laboratories, teachers feel that laboratory must be offered at scheduled times to avoid repetition for some students. This latter arrangement makes a farce of double or back-to-back periods, the two halves of which do not have the same students.

It might be quickly pointed out that interpretation of the associations presents more explanations than just the suggestive and limiting aspects of space. It may be that spatial characteristics are the indirect cause of the association. Teachers may select facilities which are appropriate for the type of teaching they prefer. Nonetheless, the use of information gained through this type of research can still be used to guide choices in design so that certain intended teaching methodologies will be facilitated.

Let me now turn to the practical use of such research. I hope some of you would like to do cooperative research in this area, but undoubtedly many of you would like some information to take home.

In a recent publication of the National Science Foundation, Science Facilities Bibliography,* the dearth of appropriate references for elementary and secondary science facilities is apparent. Although translation of requirements for universities and research laboratories is an option, such translation must be done with caution. An example of improper translation could be found in one school I visited. In the floor of the stock room a sunken lead-lined vault had been installed for the storage of radioactive substances—presumably strong gamma emitters. The general license restrictions on sale of isotopes and training in handling of clean-up operations remove the need for high cost installations. It appeared to me that some specialized facilities are more often unused monuments than they are functional components of the science laboratory.

* National Science Foundation, 1969, Science Facilities Bibliography, U. S. Government Printing Office, NSF 69-24.

Research Report No. 5 outlines many conclusions and also gives references to the original documents which contain all but anecdotal data. They are available through ERIC facilities.*

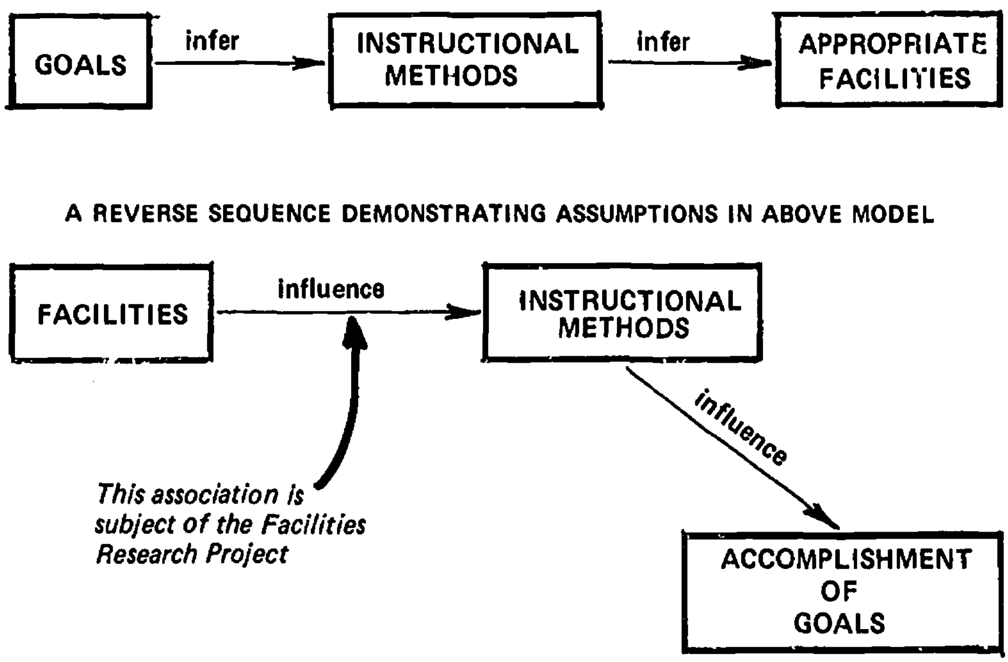
The study involved interviewing 496 teachers in more than 60 schools spread throughout Northeastern United States. New Hampshire, Massachusetts, and Connecticut were the New England states participating in the study. Each teacher was given a structured half-hour interview which included such questions as those on pages 18-20 of Research Report No. 5. Facilities were examined, but answers to interview questions were the sole source of information on teaching style. The study has a theoretical base which includes a sound administrative procedure—when contemplating new construction or renovation, the proper drafting of educational specifications is an essential activity for achievement of educational goals. This assumes a model which says certain educational goals result from certain instructional methods, and certain instructional methods can be facilitated by certain facilities; this concept is illustrated in Figure 2.

The Facilities Research Project has shown that your chances of having certain teacher practices in a future school are improved if the facilities are designed appropriately. The effort spent on drafting good educational specifications can reap benefits almost as if an invisible science supervisor were guiding the teachers. It would be unwise to give up such a chance by leaving the entire design of a facility to an architect unaided by adequate educational specifications. One should not dictate

* For those of you who may not be familiar with the ERIC system, you may contact the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, for a 25-cent pamphlet on How to Use ERIC (OE 12037). Regional offices of the Massachusetts Department of Education contain ERIC libraries as do most institutions of higher learning.

FIGURE 2

SEQUENCE FOR DRAFTING EDUCATIONAL SPECIFICATIONS



design, but should acquaint the architect with needs reflecting at least four of what I have called determinants of spatial adequacy. These are:

1. gross activities and subgroup organization (e.g., reading, titration, instrument reading, viewing opaque projections, team research in pairs, crop plant growth)

2. number of students in the space (e.g., twenty-four students per laboratory; one or two students, plus teacher, in each research stall)

3. services (e.g., gas, sunlight, electricity, water, temperature control, ventilation, air conditioning)

4. location within the school and the site characteristics to be preserved outside the school building.

When writing educational specifications, our finn adds other information, such as square footage, guidelines for which may not be available to a science department chairman. A new book which gives some technical data and new design concepts for the entire school building is N. L. Engelhardt's Complete Guide for Planning New Schools, published by Parker Publishing Company this year. The NSTA is just beginning a revision of its facilities book under a National Science Foundation Grant; the Study of Exemplary Facilities for Science Education in Secondary Schools is under the direction of Dr. Joseph Novak at Cornell. They are soliciting nominations from individuals now and will soon be visiting schools throughout the nation. I look forward to such an aid.

My 1966 publication Space Requirements for Science Instruction does give specific information regarding services which are often overlooked in educational specifications. For instance, the inability to cool an autoclave with running water may be enough inconvenience to discourage the adoption of a heavy stress on microbiology. The choice of autoclave equipment or the size of sink could be crucial here. (For example, the cooling of a pressure cooker in a drip sink can be a frustrating chore.)

The field study* has detected some interesting problems in the design of science facilities.

Some important findings deserve consideration by curriculum-oriented groups as well as building planners:

1. Microorganisms are the predominant living organism used in secondary school science, and yet neither teacher training nor the design of most laboratories takes this fact into consideration.

* D. F. Engelhardt, 1968, Aspects of Spatial Influence on Science Teaching Methods. ERIC No. ED 024 214.

2. With some notable exceptions of very dynamic teachers, most ninth graders (usually accelerated) taking biology in a junior high school do not get an inquiry-laboratory program. In these cases, the most talented science-oriented students get the least authentic, often boring, science instruction.

3. Outdoor facilities are grossly underutilized. We should heed the suggestions from Bill Stapp at the University of Michigan. Landscape design should preserve teaching stations for ecological studies. For many rural schools, such utilization of school sites could reduce cost of laboratory programs.

4. A rigorous study of ventilation requirements is needed for the aid of ventilation engineers. Is it generally known that most noxious gases generated in the chemistry laboratory are heavier than air? Is it known that plants and animals do not have the same ventilation and environmental requirements?

Some of the specific findings are now enabling us to help design better schools.

1. Schools with separate laboratories and classrooms cannot implement enquiry curriculum to the fullest.

2. Adequate storage space can support individual initiative in constructing experimental variations.

3. Improperly planned growth facilities, including small greenhouses, will stifle biological experimentation. (The use of artificially illuminated growth rooms offers a good substitute.)

4. Small sinks and inability to wash large glassware inhibit experimentation in biology.

5. The ability to send students to the library through science department corridors only increases library use.

6. Allowing teachers to have easy access to laboratory facilities after school hours can promote more experimentation, including individual projects. Provision for adequate security has design implications.

7. Second floor locations of science laboratories have significant drawbacks due to water spills, gases produced being heavier than air and tending to flow down stair wells, and inconvenience of supplying an active laboratory program not on ground floor.

8. In schools having fewer than 1,000 students, the instituting of a central supply room may increase the cost of laboratory work. Generally speaking, a stock room clerk is usually needed.

9. The absence of floor drains beneath safety showers in chemistry rooms usually leads to the water being shut off by custodians to avoid water problems on the floor.

The list is lengthy and not appropriate for a general speech of this sort. I do wish to draw these specifics together in a call for more supportive environments.

An important factor has worked toward lessening specificity of science facilities in the name of flexibility. There are flexible arrangements which can be made without shortchanging the facilities for science. During the last decade, science education has seen a deep change in methods challenging the flexibility of our schools. Flexibility became an ambiguous byword of architectural excellence. How else was there to plan a school for which the educational requirements might change several times during the building's life expectancy? Architects still take refuge in flexibility when confronted with inadequate educational specifications.

It should be apparent that spaces limit and support methods of science teaching. The question I wish to raise is: Can we have complete flexibility and still have "suggestive spaces"? In order to suggest an activity, the space must be well structured. In structuring the space, it may be found that some flexibility is lost. We may find that because of financial limitations some high school departments should specialize in only one of the research areas requiring elaborate equipment and continue as they have in other areas. To have some high schools equipped for liquid microbiological culture and others equipped for animal care is not usually considered. Why not? In effect, what I am asking for is commitment to goals, less barren flexibility, and more suggestive space.